FOLIAGE CHEMISTRY IN THE VICINITY OF ALLIED CHEMICALS CANADA INC AND GENERAL CHEMICAL CANADA LTD AMHERSTBURG, ONTARIO IN 1988, 1989 AND 1990

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FOLIAGE CHEMISTRY SURVEYS IN THE VICINITY OF ALLIED CHEMICALS CANADA INCORPORATED AND GENERAL CHEMICAL CANADA LIMITED AMHERSTBURG, ONTARIO IN 1988, 1989 AND 1990

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1 Introduction

Allied Chemicals Company Incorporated (ACCI) and General Chemical Company Limited (GCCL) operate chemical production plants immediately north of the town of Amherstburg in southwestern Ontario. While these companies are discrete corporate entities, they occupy a common industrial property, and were one company, Allied Chemical Company Limited, prior to 1986.

According to an Allied Chemical Company Limited information brochure, the primary production facilities of what are now these two companies, occupy a site of approximately 500 acres. This does not include various quarry and brine well properties. This site, which will be referred to as the "industrial complex", is bordered on the west by Highway 18 and the Detroit River, and on the east by other industrial and agricultural lands.

Lands to the north consist of vacant fields, scrub bush and agricultural fields. However, residential properties are located immediately north of these lands. Distances between the industrial complex fence line and these residential properties are on the order of 200 metres.

The southern boundary of the industrial complex is shared by agricultural fields, other industrial properties and, in the western portion, by residential properties of the town of Amherstburg.

ACCI produces hydrofluoric acid and chlorofluorocarbons. GCCL produces sodium carbonate and calcium chloride. Raw materials, products and by-products involved in the industrial processes employed by both companies include both common and exclusive chemical elements. Both companies handle calcium and chlorine compounds. However, sodium is involved only in GCCL processes and fluorine only in ACCI processes.

While it is the usual practice of the Phytotoxicology Section to report on surveys around industrial sources in separate and distinct reports, there is sufficient justification to combine these two assessments in a common report. Such justification includes:

1. Common elements in industrial processes with potential of environmental contamination by these elements by either company
2. Common operating site
3. Previously one company
4. Common sampling stations in Phytotoxicology survey
5. Report is public document

2 Previous Phytotoxicology Section Surveys

The Phytotoxicology Section of the Air Resources Branch has been actively monitoring contamination of vegetation by emissions from these industrial sources. The report "Phytotoxicology Assessment Survey Investigation in the Vicinity of Allied Chemical Canada Limited and General Chemical Canada Limited, Amherstburg, Ontario - 1987" contains details regarding the industries, the nature of previous Phytotoxicology surveys, and analyses of current (1987) data as well as data trends in time through the use of historic data. This report will be referred to as the "1987 report".

Since much of the information will not be repeated here, the reader is advised to consult the 1987 report for background information.

Other monitoring activities, conducted by the Ministry in the vicinity of the complex consist of a network of fluoridation candles and a suspended particulate sampler. Two additional suspended particulate samplers were established in early 1991 to monitor particulate emissions from the complex. These monitoring activities will be discussed later in this report.

3 Phytotoxicology Surveys in 1988, 1989 and 1990

This report will describe the nature of survey activities conducted in 1988 to 1990, present the results of these surveys and offer analysis and interpretation.

There were two distinct survey designs utilized during the period from 1988 to 1990. The first was a continuation of sampling of silver maple foliage from long-established survey stations. The second consisted of a new network of sites at which foliage from cottonwood trees was collected.

3.1 Silver Maple Survey

The design of this survey was fully described in the 1987 report. Briefly, the survey consisted of nine stations (trees) which were visited five times during the growing season, at the ends of the months of May through September. Triplicate samples of foliage were taken from the sides of silver maple (*Acer saccharinum*) trees facing the industrial complex.

In 1988, this survey was continued with samples being taken at end of the months of May and June. However, a Ministry wide fiscal restraint curtailed all Phytotoxicology survey activity for the remainder of 1988. Consequently, only two sets of samples were obtained.

In 1989, survey resources were directed to the new survey design described below. However, two visits to the maple stations at the ends of the months of July and August (actually Sept. 5) were conducted to maintain some continuity in the data base for the silver maple stations.

The collection, sample processing and chemical analysis procedures employed in 1988 and 1989 were identical to those employed previously. There was one change made in the station configuration. Namely, Station 65 was discontinued because it could potentially be influenced by another industrial source in the area. Station 15 was established as a new, more distant control station. The locations of these stations are represented in the map comprising Figure 1. The results of the chemical analyses of the samples are given in Appendix 1, along with the arithmetic means and standard deviations of the triplicates.

Note that the analytes consist of sodium, chlorine, calcium and fluoride. Fluoride was determined in both washed and unwashed tissue. Because the method of analysis reports total concentrations of the elements sodium, chlorine and calcium, references to these analytes will be by their element name. However, since fluoride concentrations are determined on a weak acid extraction of the tissue by ion electrode, reference to this analyte will be by the ion name, fluoride. Under no circumstances is it inferred that the reactive gases Cl_2 or F_2 are involved in any of the foliar chemistry results.

The means of the triplicate samples collected in 1988 and 1989 at the nine stations are graphically represented in Figures 2 through 5. These figures represent concentrations of fluoride in unwashed and washed tissue as well as sodium and chlorine in unwashed tissue.

Calcium concentrations, although presented in Appendix 1, are not graphed. Although calcium compounds are utilized by both companies, GCCL personnel have acknowledged that emissions can be attributed primarily to the lime kilns operated by their company. However, the naturally high background concentrations in foliar tissue precludes foliage chemistry as a viable method to assess calcium emissions to the air. Consequently, calcium data will not be discussed in this report.

Following are discussions of the 1988 and 1989 silver maple foliage chemical data.

3.1.1 Fluoride in Unwashed Silver Maple Foliage

The concentrations of fluoride in exposed, unwashed silver maple foliage (Figure 2) display a wide range. The relative concentrations between stations, when examined against the backdrop of the station locations, identifies the industrial complex as the source area. Since GCCL does not manufacture or utilize compounds containing fluoride, emissions and contamination of the foliage can be ascribed to ACCI.

Concentrations at the same station can change significantly in the period of one month. Evidence of this is seen in the Station 16 data for July and August, 1989 samples.

Fluoride concentrations in silver maple tissue well removed from an industrial source, such as at Station 15, are on the order of five micrograms per gram (ug/g). Stations close to the source, and presumably downwind for a period of time before sampling, are contaminated with concentrations for most sites in excess of 50 ug/g and as high as 200 ug/g.

Although the limited and unsynchronized sampling programs in 1988 and 1989 precludes direct comparison, generally, concentrations encountered in the 1989 samples appear lower than those of 1988.

The concentrations encountered can be compared to Phytotoxicology Upper Limits of Normal Guidelines (ULN). These guidelines represent the highest concentrations that should be encountered in foliage samples that are not influenced by industrial sources in close proximity. These guidelines, which are 15 ug/g for rural samples and 35 ug/g for urban samples, were routinely exceeded in samples taken in the vicinity of the ACCI operation.

While ULN guidelines are not enforceable as standards, the consistency and degree with which they continue to be exceeded represents a potential for injury to sensitive plant species and warrants further assessment of controls on known sources of emissions as well as an investigation of all potential fugitive sources within the ACCI operation.

3.1.2 Fluoride in Washed Silver Maple Foliage

Fluoride in washed silver maple foliage is represented in Figure 3. These data parallel those of the companion unwashed samples; however, the absolute concentrations are lower. This indicates that some of the fluoride is either on the surface of the foliage, or was leached from the foliage in the washing process. Since significant amounts of fluoride are taken into the plant tissue, the potential for injury of foliar tissue is of concern.

Washing of foliage prior to fluoride analysis was also performed for historic reasons. Control Orders were in place in the 1970's which required limiting fluoride concentrations in washed silver maple foliage. The limit was 100 ug/g. The concentrations in the May and June, 1988 samples from Station 1; and the June, 1988 samples from Station 16 exceeded the former Control Order limits. It is notable that none of the 1989 samples exceeded this limit.

3.1.3 Sodium in Unwashed Silver Maple Foliage

Sodium releases to the atmosphere are attributable to GCCL since ACCI does not utilize or produce compounds containing this element. Sodium concentrations in silver maple are represented in Figure 4. As with fluoride, concentrations of sodium

display a wide range. The highest concentrations were encountered at Stations 16, 18 and 31. Considering that prevailing winds are from the south to southwest, contamination of foliage at Station 31 is consistent with emissions from GCCL. Stations 16 and 18 are upwind of the prevailing winds, but are the closest stations to the GCCL operation. It should be noted that winds can and do blow from all directions at some time. Consequently, the contamination at these stations is also consistent with emissions from GCCL.

The Phytotoxicology ULN guidelines for sodium in tree foliage are 50 ug/g in rural samples and 350 ug/g in urban samples. The only station where the rural guideline is not exceeded is the control Station 15. The urban guideline was exceeded regularly at Stations 16, 18 and 31. The highest concentration was 787 ug/g at Station 31 in May, 1988. This concentration is typical of those encountered in 1987, but considerably less than the 1700 ug/g also seen in 1987. (See Figure 4 in 1987 report)

It should also be noted that, subject to the intercomparison limitations, the 1989 concentrations appear to be lower than the 1988 concentrations. However, the ULN guidelines were still exceeded.

3.1.4 Chlorine in Unwashed Silver Maple Foliage

Figure 5 represents the chlorine concentrations encountered in 1988 and 1989. The most notable difference between these data and those for fluoride and sodium is the relatively small differences in concentrations between the stations close to the source and those at greater distances. For example, sodium concentrations at the more impacted stations are an order of magnitude higher than the control station concentrations, while, differences in chlorine amount only to a factor of two.

The highest chlorine concentrations occur at the same stations where excessive sodium was encountered, suggesting a common source and perhaps a common compound containing both sodium and chlorine. Since there is no urban ULN guideline for chlorine, only the rural guideline of 0.15 % can be used in any

comparison. Such a comparison reveals regular exceedances of this concentration. However, such exceedances also occur at control Station 15.

Such an observation, which has been made not only at stations around this industrial complex, but also in surveys near other sources, suggests that the ULN guideline for chlorine is not appropriate for silver maple foliage in this geographical area. Consequently, while chlorine does appear to originate from this industrial complex, the significance of the resulting contamination cannot be evaluated.

3.1.5 Long Term Concentration Trends

The 1987 report, in addition to examining 1987 data, looked at long term trends in foliage chemistry. There were six stations that had been sampled since 1975 and the foliage analyzed for fluoride, sodium and chlorine. Sampling occurred five times each summer. The means of the six stations over the five sampling dates were used in the trend analysis.

Although these six stations were sampled in 1988 and 1989, they were only sampled two times each year. Consequently, a full trend analysis could not be continued. However, to permit at least a partial evaluation of the trends, Figures 6, 7, 8 and 9 have been prepared. These figures plot the monthly means of the six stations (1, 16, 18, 29, 30 and 31) when data are available.

Figures 6 and 7 represent these six station means for each sampling date since 1975 for fluoride in unwashed and washed foliage. When the May and June, 1988 histograms are compared to the comparable months since 1975, very little, if any, change in foliar contamination is apparent. However, the July and August, 1989 concentrations appear noticeably lower than in those months in most years back to 1975.

Figure 8 is an identical representation for sodium in unwashed foliage. Here the May and June, 1988 concentrations appear to be comparable to those since 1985, but generally lower than those prior to 1985. The August 1989 concentration is also similar to those since 1985; however, the July, 1989

concentration is the lowest monthly multi-station mean encountered in the history of Phytotoxicology surveillance around this industrial complex.

Because of the limited data base further analysis and interpretation of trends cannot be undertaken. Caution should also be exercised in relating these findings to changes in industrial emissions, as other environmental or climatic factors may be contributing to these observations. It should be noted that in 1991, the complete nine-station, five-sampling date silver maple survey has been re-established and will permit additional trend analyses in the future.

Figure 9, representing the identical representation of chlorine in unwashed foliage has been included in this report for information only. Trend analysis will not be attempted for reasons outlined in Section 3.1.4.

3.1.6 Foliar Injury Observations

During previous silver maple surveys, the foliage on the sampled branches has been examined for indications of injury that could be ascribed to industrial emission impacts. Such examinations were conducted in 1987 and discussed in the 1987 report. This discussion revealed the difficulties with ascribing injury symptoms on this foliage to a specific contaminant. Consequently, in 1988 and 1989 formal notation of fluoride-like or sodium-like injury symptoms was not performed during the collection surveys.

3.2 Complaint Investigations

Each year the Phytotoxicology Section is requested to investigate allegations of injury to vegetation on residential properties, primarily on Texas Road, north of the complex. In the majority of these investigations, the injury is inconsistent with the symptoms that would be observed if one of the industrial contaminants was the primary causal agent. Such injuries are ascribed to diseases, insects and physiological stress. However, on occasion, symptoms on vegetation are indicative of some influence by either the GCCL or ACCI operation.

In 1988, there were three cases where calcium dust from the GCCL lime kiln operation was noted to have impinged on and coated the boles of fruit and ornamental trees on residential properties. Such coating is not necessarily injurious to the tree, but does have a negative aesthetic effect.

In 1989, there was one case of trace injury to tree foliage that was symptomatic of fluoride and was so ascribed. In 1990, there was one case of injury to ornamental trees that was attributed, in part, to sodium and fluoride contamination. It must be emphasized that investigations of alleged injury to vegetation on private properties are only conducted on the request of the property owner.

3.3 Cottonwood Survey

In 1989, a new vegetation survey design was developed to improve the resolution of the locations of the sources of contaminants emitted by the two industries and to evaluate the relative impacts over distance.

To meet these objectives, the stations required a common tree-species that was available at sites very close to the sources as well as at various distances along transect lines. A reconnaissance of the area revealed that the only suitable tree species was eastern cottonwood (*Populus deltoides*).

Figure 10 displays the distribution of these new sampling stations. Note that there are three series of station designations, identified with the alphabetic characters A, B and C. Stations A1 to A6 are accessible via a trail running parallel to the northern boundary of the industrial complex. It should be noted that some of these stations, and possibly Station A8, may be located on lands owned by either ACCI or GCCL. If such is the case, then the stations are within a few metres, at most, from land owned by other parties. This point is made so that in the forthcoming evaluation of contamination of foliage at a station occurring on ACCI or GCCL property, it can be considered comparable to a station which might have been immediately beyond company property.

All remaining stations are on residential properties. Station A7 is in the front yard of a Texas Road residence. Stations B1 to B4 are in the back yards of Second Concession residences. Stations C1 and C2 are located on residential properties in the town of Amherstburg. Station C3, not shown in Figure 10, is a control station approximately six kilometres south of the industrial complex.

The method of sampling of foliage was identical to that used in the silver maple survey. Triplicate samples of foliage were taken from the side of the tree facing the industrial complex. Sampling occurred on July 27, 1989 and August 16, 1990. Samples were processed and analyzed for fluoride, sodium, chlorine and calcium on an unwashed basis. There was no laboratory washing of foliage. The results of the individual sample analyses, along with arithmetic means and standard deviations are contained in Appendix 2.

Means of triplicate samples for each station are represented in the paired Figures 11a and 11b, 12a and 12b and 13a and 13b for fluoride, sodium and chlorine, respectively. Calcium data are not presented or discussed for reasons given for the silver maple data. Note that the "a" figures are 1989 data and the "b" figures are 1990 data.

To enhance the data interpretation, prevailing wind records from Windsor airport were analyzed. This is the nearest meteorological station recording wind directions and it is probably reasonably representative of Amherstburg winds. Hourly prevailing winds for up to 28 days prior to the sampling dates were summed for each of 16 compass points, plus calm conditions. Prevailing wind patterns for 7, 14 and 28 day periods prior to sampling were examined. Figures 14a and 14b represent the 14 day winds in 1989 and 1990, respectively. The 7 and 28 day winds showed virtually identical patterns and are, therefore, not presented.

3.3.1 Fluoride in Cottonwood Foliage

Figures 11a and 11b represent concentrations of fluoride in cottonwood foliage. The y-axes scales in these figures are

matched to facilitate comparisons between years. The most dominant feature of these figures is the difference in maximum concentrations between years; 51 ug/g at Station A6 in 1989 and 137 ug/g at Station 5 in 1990. The second highest concentrations in each year also occurred at these two stations. Also worth noting are the relatively high concentrations encountered at Station C1 in both years.

With the exception of the three stations mentioned above, all other stations had concentrations only marginally above or below the rural ULN guideline of 15 ug/g. This illustrates a limited impact zone. However, it must be emphasized that these results cannot be compared with those from previous years in which silver maple was sampled. The differences in the morphology and physiology between these species would result in different foliar concentrations under similar air concentrations of fluoride.

The map of the station locations, Figure 10, indicates the relative position of the suspected source of fluoride, the hydrofluoric acid plant operated by ACCI. The initial conclusion would be that given prevailing southerly to southwesterly winds, the source of fluoride is the HF plant. However, by examining the wind data for the 14 day periods before sampling, a more detailed analysis is possible. Figures 14a and 14b reveal real differences in wind conditions in 1989 and 1990. The 1990 wind frequencies are more typical of the area, ie. S to SW. However, in 1989, there was a high frequency of winds from the NE as well as from all other directions. Such NE winds may account for the elevated fluoride concentration at Station C1 in 1989. Note that this concentration is similar in magnitude to those at Stations A5 and A6.

In 1990, when typical S to SW conditions returned, the highest concentration was at Station A5, north of the industrial complex. However, a closer examination of the position of Station A5 shows that it is NNW of the HF plant. It would require SSE winds to impact this station if the HF plant was the sole source. SSE winds were infrequent. These observations, which allude to a source of fluoride other than, or in addition

to the HF plant, must be considered in light of the uncertainty in applying Windsor wind data to Amherstburg. However, additional support is provided in the relatively low concentrations at Station A6 in 1990. This station is NE of the HF plant and would be impacted by emissions from the plant under the generally prevailing SW winds.

While these observations are subject to some degree of uncertainty, there remains a strong suggestion of a source of airborne fluoride to the west of the HF plant and east of the chlorofluorocarbon plant. An investigation of possible sources in this area by Ministry abatement staff and ACCI staff is warranted.

3.3.2 Sodium in Cottonwood Foliage

Sodium concentrations are represented in Figures 12a and 12b for 1989 and 1990, respectively. These figures indicate elevated concentrations at Stations A1 through A6, peaking at A6. Station B1 also has elevated concentrations and will be discussed later.

In 1990, there was a trend of increasing concentration proceeding from west to east in these six stations. This trend was especially distinct in Stations A4 through A6. Upon examining the wind data in Figure 14b, one can conclude that the sodium carbonate plant operated by GCCL is the source of the sodium contamination.

In 1989, there is much less of a concentration trend through these stations. Station A6 stands out as having a distinctively higher concentration than any other station. Also lacking is any evidence of notably elevated sodium at Stations C1 or C2 as compared to 1990, despite the NE winds of 1989. This later observation contrasts with what was seen for fluoride in 1989 when winds blew more frequently from the NE. It may be argued that the sodium emissions, being particulate in nature, are being removed by impingement on other vegetation located between these sites and the emission source.

The high concentration at Station A6 in 1989 suggests the possibility of incidental release(s) of sodium compounds from the GCCL operation. A similar conclusion was drawn in the 1987 report based on 1987 silver maple data.

Station B1 exhibits unexpectedly high sodium concentrations in both years. Station A7, which is in a line with the sodium carbonate plant and Station B1, has low concentrations. The concentrations in 1989 and 1990 are of similar magnitude despite differences in wind patterns. There are strong indications of a sodium source other than the industrial complex. Such a source becomes identifiable when the characteristics of Station B1 site are examined.

Station B1 is located at the extreme west of a residential property on the west side of the Second Concession Road. A railway line is a few metres away. The Station B1 tree is at an elevation lower than the railway bed. This rail line is used by hopper cars transporting sodium carbonate. Spillage from the hoppers is very common. Piles of sodium carbonate are situated throughout on the rail beds. Rain dissolving this material could wash it into the rooting zone of the tree at Station B1.

The transport of sodium carbonate in not under the control of GCCL; rather, it is the responsibility of a railway company. Apparently, it is the practice of the railway to keep the hopper doors of "empty" cars open. Shunting of the cars causes residual sodium carbonate to discharge onto the rail bed. While the Ministry's Windsor District Office has expressed concern about this problem to the railway, there have been no amendments made to the transportation practices. It should be noted that railway operations are under federal jurisdiction.

The effect of these transportation practices is to distribute a contaminant to areas which would not otherwise be significantly impacted by atmospheric deposition.

To this point, there has not been any discussion of injury to the cottonwood sample trees. When this survey was designed, it was recognized that this species was not particularly sensitive to the chemicals emitted by the two companies. In fact, with one exception, injury was not observed on the sampled

trees. During the 1989 sampling, foliage of the tree at Station A6 was distinguished with light to moderate marginal necrosis of approximately 10% of the leaves. This observation was recorded. The chemical data for this station indicate an exceptionally high concentration of sodium (8000 ug/g). As the fluoride concentration was not similarly excessive (51 ug/g) and well below the range where phytotoxicity would result for this relatively fluoride-tolerant species, the injury can be attributed to sodium contamination.

As was mentioned previously, some of the stations north of the industrial complex were situated on ACCI or GCCL property. Station A6, according to maps in the possession of the Phytotoxicology Section is located off either company's property and only a few metres from an agricultural field.

3.3.3 Chlorine in Cottonwood Foliage

Chlorine concentrations are displayed in Figures 13a and 13b. While elevated concentrations are definitely apparent at Stations A4 and A5 each year and occasionally coincide with increases in sodium, the correlation is not strong. Also, the background concentrations are very variable and in some cases, approach the chlorine concentrations found at the sodium impacted stations.

Foliar chemical analysis appears to be an inadequate method of detecting and ascribing chronic level chlorine contamination impacts from atmospheric sources.

4 Fluoride Candle Monitoring

Since 1975, the Southwest Region has maintained a network of lime candles in the vicinity of the complex. These candles consist of filter paper soaked in a suspension of calcium oxide and wrapped onto a glass cylinder. This candle is positioned in the field for a one month period. Fluoride compounds in the air react with the calcium oxide and are retained on the paper until laboratory analysis.

The candles do not provide direct measurements of gaseous or particulate fluoride compounds in the air. Data are expressed as fluoridation rates which reflect the amount of fluoride which has reacted with a unit surface of the candle over a fixed period of time. The Ambient Air Quality Criteria in Regulation 296 of the Environmental Protection Act for fluoridation rate are 40 ug F/100 cm^2/30 days for the period April 15 to October 15 and 80 ug F/100 cm^2/30 days for the period October 16 to April 14. More recently the Ministry of the Environment amended the growing season definition to recognize differences in northern and southern Ontario. For the Amherstburg area, the growing season now applies to the period from April 1 to September 30.

Six fluoridation stations in the vicinity of the complex were active in 1990. Four of these were located within the area of the silver maple sample stations, but only three have been active since 1975. Fluoridation rate data from these three stations are used in this report to compare trends in these measurements with trends encountered in the fluoride concentrations in silver maple foliage.

Fluoridation rates from all six, currently active, sations are tabulated in Appendix 3. This tabulation is restricted to the April through September growing period exposures. These data were retrieved from the Air Quality Information System (AQUIS) database.

This period encompasses the period during which silver maple samples were collected. Arithmetic means for the six exposure months and the three stations were calculated. Figure 15 represents these mean fluoridation rates from 1975 to 1990. These calculations parallel those used in calculating mean foliar fluoride concentrations in the 1987 report where six station by five collection date means were generated. Note that there were no fluoridation rate data for 1982, 1983 and 1984 in AQUIS.

The 1987 report noted that there was no discernable trend toward lower concentrations of fluoride in silver maple foliage during the period 1976 to 1987. Section 3.1.5 in this report notes the lack of lower concentrations in 1988, but reports some indication of lower foliar concentrations in 1989.

Figure 15 partially supports the steady-state condition encountered in the silver maple foliage. This figure indicates that from the period 1979 to 1989, fluoridation rate means have been fairly constant. In fact, the mean rate of 1976 is also similar. The mean fluoridation rates of 1977 and 1978, however, do appear to be higher. Such elevations were not encountered in the foliage means in those years.

Also, the apparent decrease in silver maple foliage fluoride in 1989 as compared to 1988, discussed in Section 3.1.1, is not reflected in the fluoridation rates for these two years. Unfortunately, the relatively low fluoridation rate mean of 1990 cannot be compared to silver maple concentrations, as such vegetation samples were not collected.

This exercise demonstrates that, while the two monitoring methods - tree foliage chemistry and lime candles - are complementary in assessing long term trends, they cannot be used to make direct comparisons with limited numbers of observations.

This is not unexpected, given the numerous factors that affect plant uptake, accumulation and loss of fluoride which would not similarly affect a physical (static) receptor located in a rain protected shelter.

It should be noted that, as with fluoride in vegetation, where the Upper Limit of Normal guidelines have been and continue to be exceeded, the Ambient Air Quality Criterion for fluoridation rate has likewise been regularly exceeded. Cases of exceedance of the 40 ug F/100 cm^2/30 day criterion have been highlighted in bold text and frequency of exceedances summarized in Appendix 3.

5 Suspended Particulate Monitoring

The AQUIS database also contains data on suspended particulate concentrations as monitored at one of the lime candle sites, site 12053, between 1981 and 1990. Suspended particulates are monitored by drawing ambient air through, and capturing the particulates on, a filter. Such Hi-Vol samplers are operated for 24 hour periods on a six day cycle. The Ambient Air Quality Criterion for suspended particulates is 120 ug/m^3/24 hours.

For the period 1981 to 1990, there are 502 daily suspended particulate concentration data in the AQUIS. On twelve occasions the criterion was exceeded. Eleven of these occurred in 1981 through 1985. Since emissions by GCCL are likely to be particulate in nature, it would have been useful to compare air particulate concentrations with foliar chemistry. However, suspended particulate concentrations would include all particles in the air, not just those emitted by GCCL. Furthermore, the chemical composition of the particles is not determined, and the geographic position and intermittent operation of this single monitor is not optimal for tracking trends in GCCL emissions.

Early in 1991, two addition sites for particulate monitoring were established. These sites are optimized for monitoring GCCL emissions.

6 Summary and Conclusions

Two chemical production facilities occupy a common industrial complex in the vicinity of Amherstburg. Allied Chemicals Canada Incorporated (ACCI) manufactures hydrofluoric acid and chlorofluorocarbons. General Chemical Canada Limited (GCCL) manufactures calcium chloride and sodium carbonate. Emissions from these industries include fluoride compounds in the case of ACCI; and sodium compounds in the case of GCCL. GCCL can also release calcium compounds. Compounds containing the element chlorine can potentially be released by either company, or by a third, unrelated, company in the vicinity.

Emissions of fluoride and sodium can result in contamination of vegetation in the area of the complex, and result in injury to foliar tissue.

In 1988, 1989 and 1990, the Phytotoxicology Section conducted two types of vegetation surveys in the vicinity of the industrial complex. These surveys investigated the degree of foliar contamination by emissions from these operations. Complaints from neighbouring residents alleging vegetation injury caused by emissions were also investigated as received.

In 1988 and 1989, silver maple foliage was collected at nine established stations. However, these collections occured two times in each of the two years. A continuation of the analyses of trends in foliar contaminant concentrations, which was initiated in the 1987 report could not be continued since previous collections were conducted five times each year.

In 1989 and 1990, a new survey design was employed to identify the sources of the contaminant releases and the geographic extent of their impacts. The survey consisted of transect lines of cottonwood trees from which foliage was sampled and analyzed. The data were interpreted with the aid of prevailing wind information for the period preceding the sampling.

6.1 Allied Chemicals Canada Incorporated

Analysis of silver maple foliage for fluoride revealed elevated concentrations. These concentrations frequently exceeded the Phytotoxicology Upper Limit of Normal Guidelines. Despite the limitations imposed on the continuation of any trend analysis by the reduced sampling frequency, concentrations encountered in 1988 were similar to those encountered in other recent survey years. However, the 1989 samples had notably lower concentrations of fluoride.

In 1989 and 1990, the new cottonwood surveys revealed elevated concentrations of fluoride in cottonwood foliage at stations north of the general area of fluoride production or use. However, a more detailed examination of the contamination patterns with the aid of wind data, suggests the possibility of a source or sources of fluorides in addition to the hydrofluoric acid or chlorofluorocarbon facilities. In 1989, a higher frequency of NE winds resulted in more notable contamination of stations in the northern part of the town of Amherstburg.

Neither survey design included examination for, or confirmation of injury induced by fluoride. However, complaints from residents were examined, and in two cases, it was concluded that fluoride contributed to injury of the vegetation.

In this report, data generated by passive fluoride monitors (lime candles) are examined and trends compared to trends in silver maple fluoride concentrations. There is reasonable agreement with respect to a lack of notable reductions in the degree of air borne fluoride contamination in the vicinity of ACCI over the past 10 or more years

On the basis of these findings, additional Ministry of the Environment investigations of fluoride emission sources and abatement possibilities are warranted to reduce the degree and extent of contamination and reduce or eliminate the potential for injury to vegetation.

6.2 General Chemical Canada Limited

Analysis of silver maple foliage for sodium revealed elevated concentrations. These concentrations frequently exceeded the Phytotoxicology Upper Limit of Normal Guidelines. Despite the limitations imposed on the continuation of any trend analysis by the reduced sampling frequency, concentrations encountered in 1988 were similar to those encountered in other recent survey years. However, the 1989 samples had notably lower concentrations of sodium.

In the cottonwood surveys, sodium concentrations in cottonwood foliage were highly elevated north of the plant. There was evidence of a trend of increasing concentrations from west to east along the transect line which was parallel to the northern boundary of the industrial complex. An exceptionally high concentration at one station was detected in 1989. Injury to the cottonwood foliage at this station was attributed to this high sodium concentration.

Sodium was also ruled as contributing to foliar injury, along with fluoride, in one complaint investigation.

This survey also revealed a problem with the transport of sodium carbonate. Spillage of this material from railway hopper cars is constantly observed along the railway bed near the complex, and contributes to contamination of vegetation, through

root uptake, well away from the manufacturing site. It is acknowledged that this material is not under the control of GCCL when spilled.

While not causing direct injury to foliage, or notably elevating the concentations in the foliage, calcium dust emissions are having deleterious aesthetic effects on tree boles.

On the basis of these findings, additional Ministry of the Environment investigations of sodium emission sources and abatement possibilities are warranted to reduce the degree and extent of contamination and reduce or eliminate the potential for injury to vegetation. Similar interventions with respect to calcium dust emissions would result in reduced negative aesthetic effects.

7 Figures

FIGURE 1: SILVER MAPLE STATION LOCATIONS - ACCI/GCCL SURVEY - 1988 & 1989

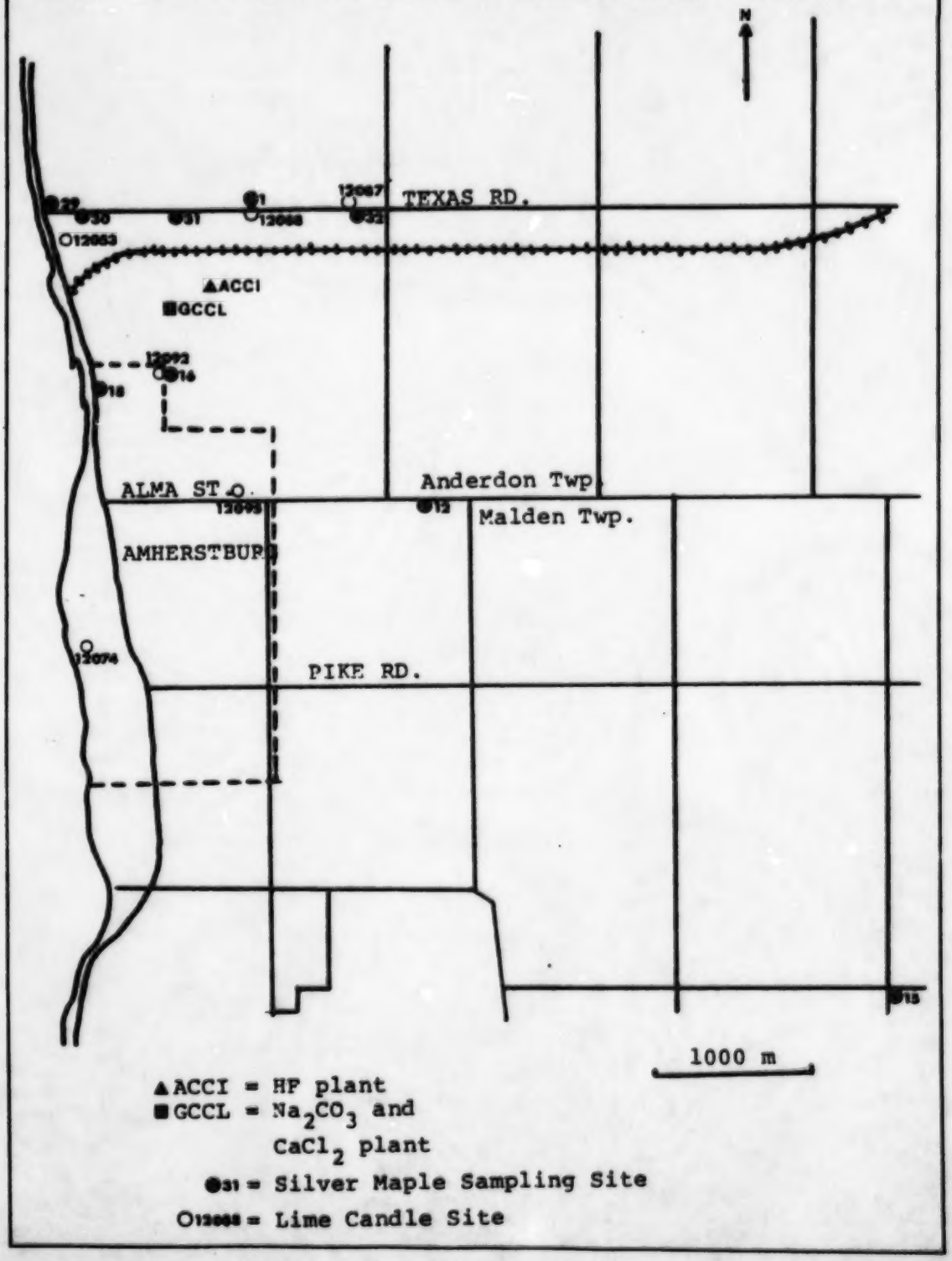
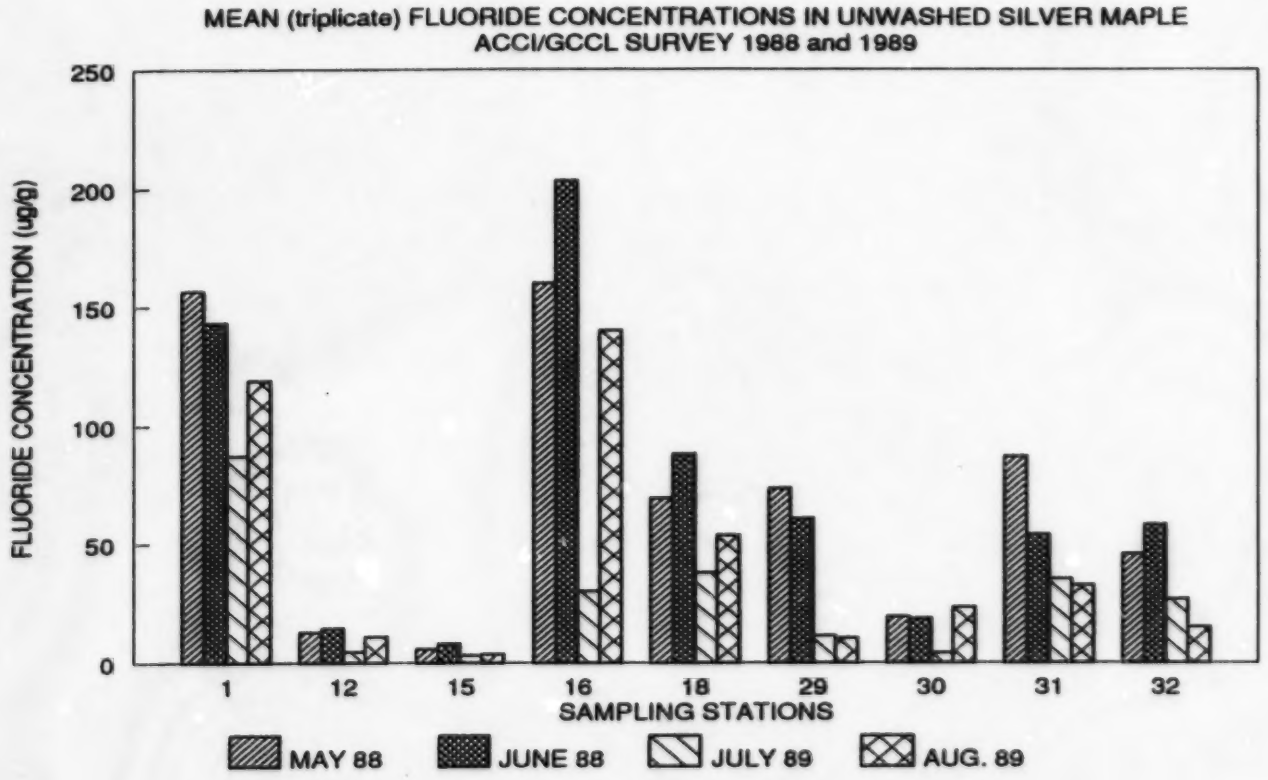


FIGURE 2:



D:\AG-88-89\FFUW8889.CGM

FIGURE 3:

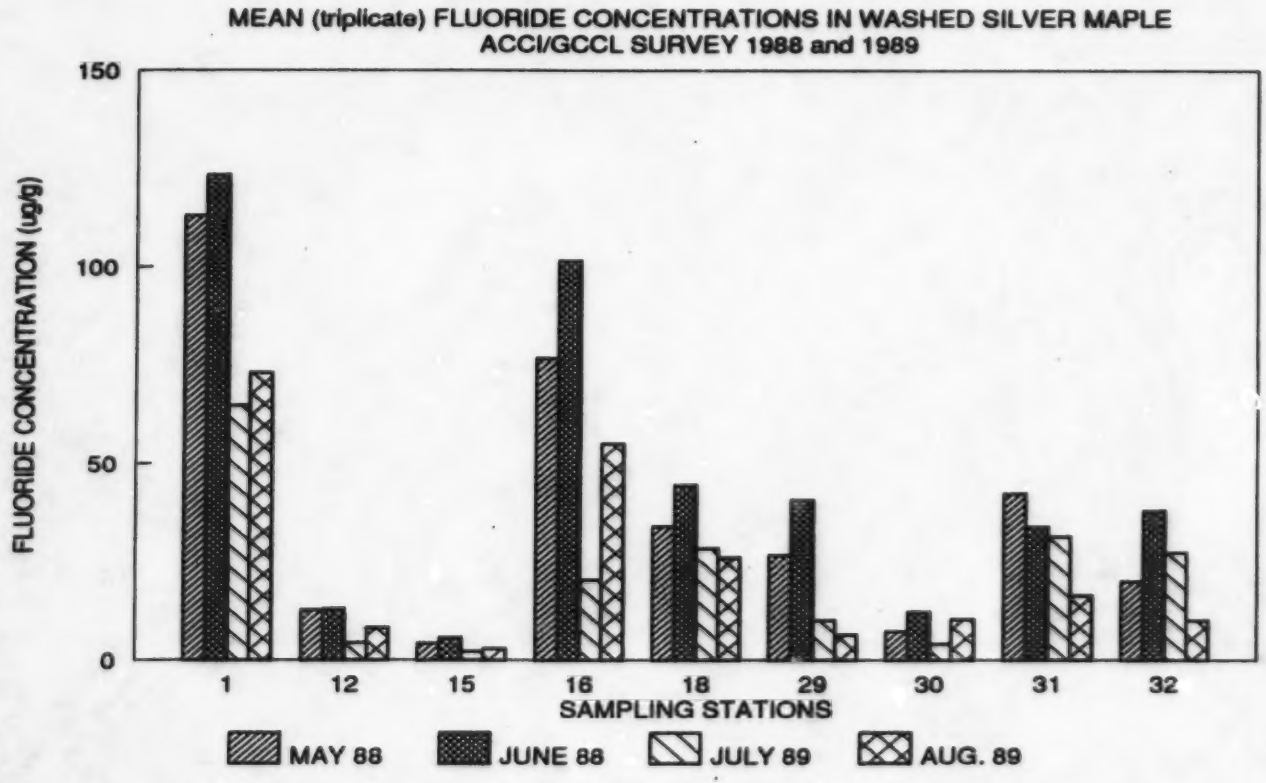

MEAN (triplicate) FLUORIDE CONCENTRATIONS IN WASHED SILVER MAPLE
ACCI/GCCL SURVEY 1988 and 1989
FLUORIDE CONCENTRATION (ug/g)
150
100
50
0
1
12
15
16
18
29
30
31
32
SAMPLING STATIONS
MAY 88
JUNE 88
JULY 89
AUG. 89

FIGURE 4:

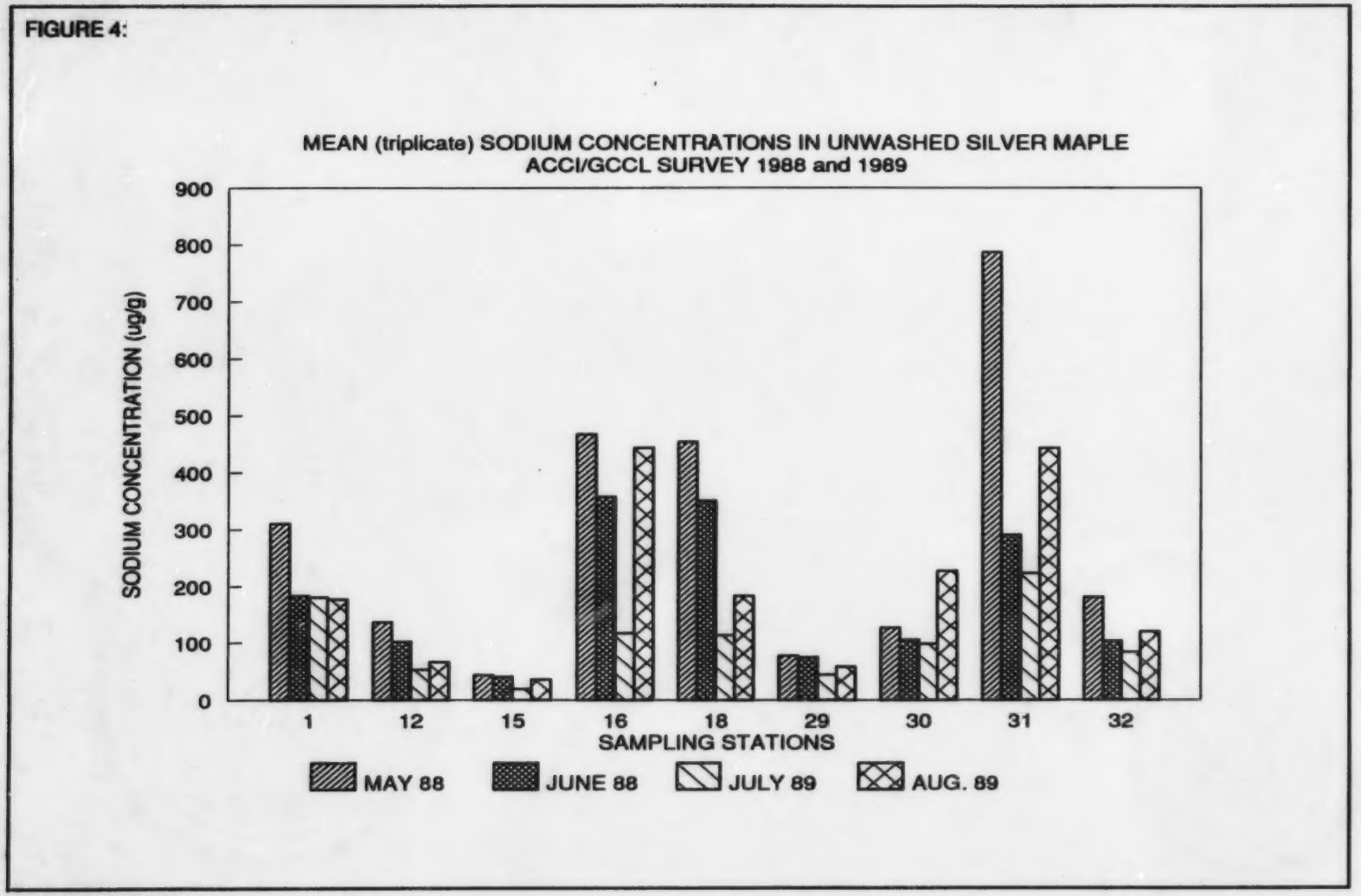


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FIGURE 5:

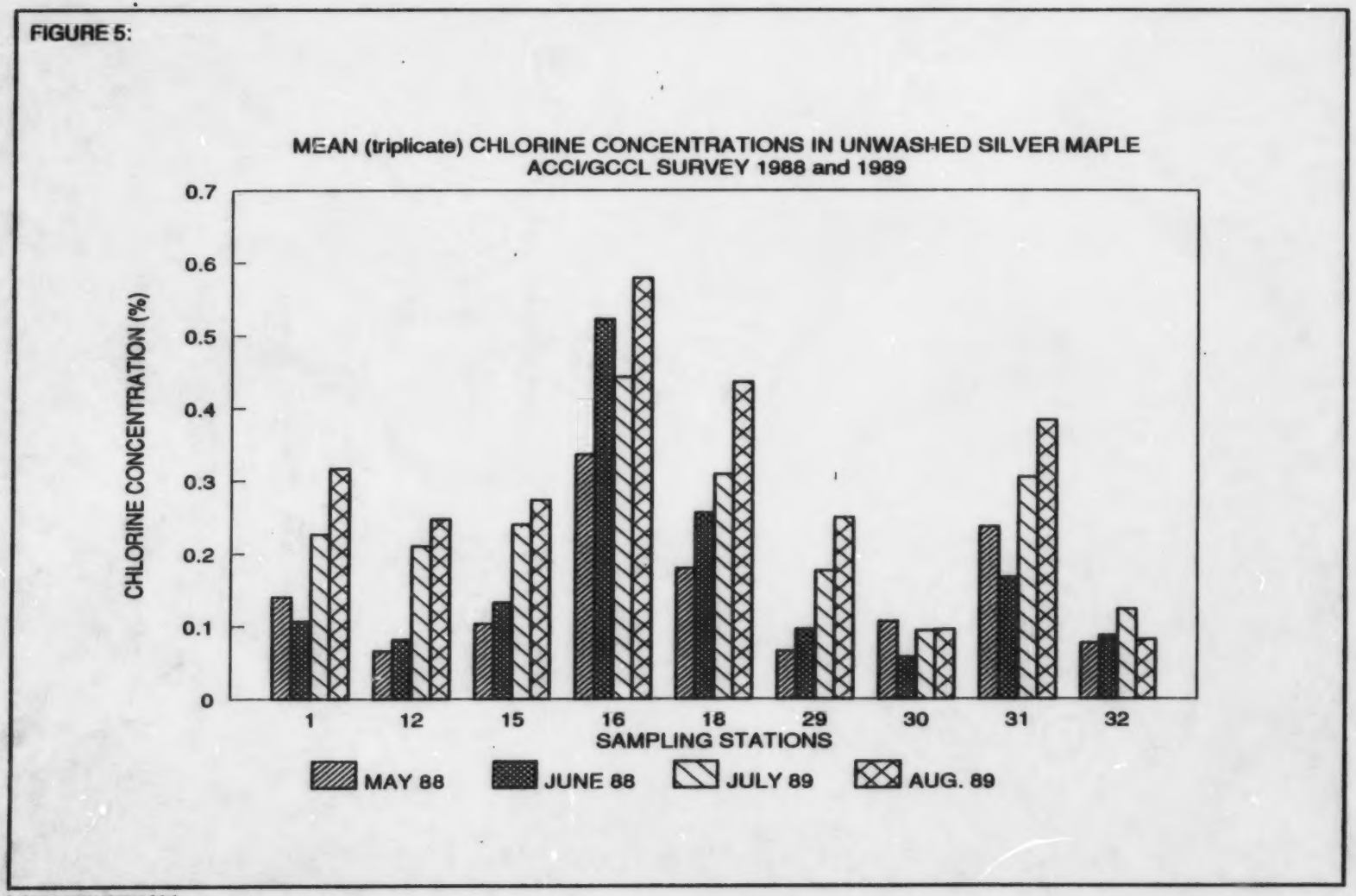

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FIGURE 6:

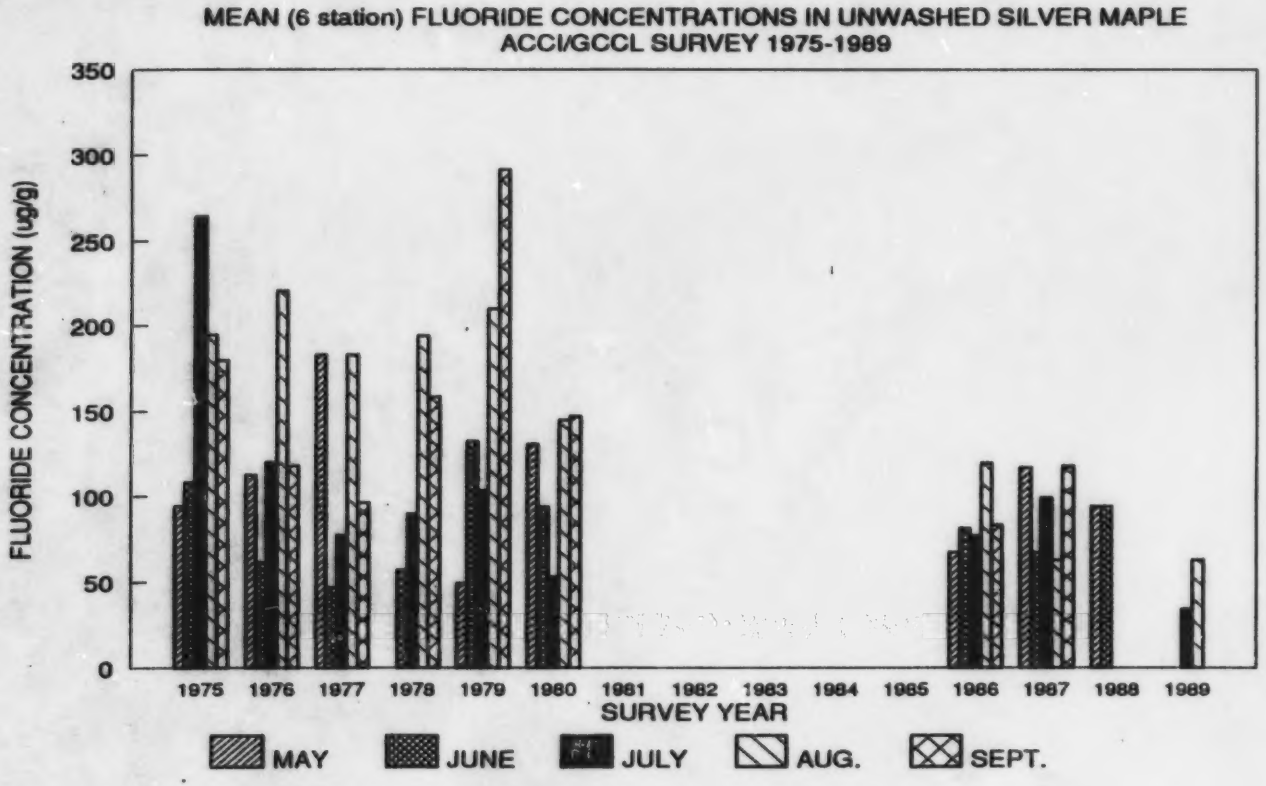

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FIGURE 7:

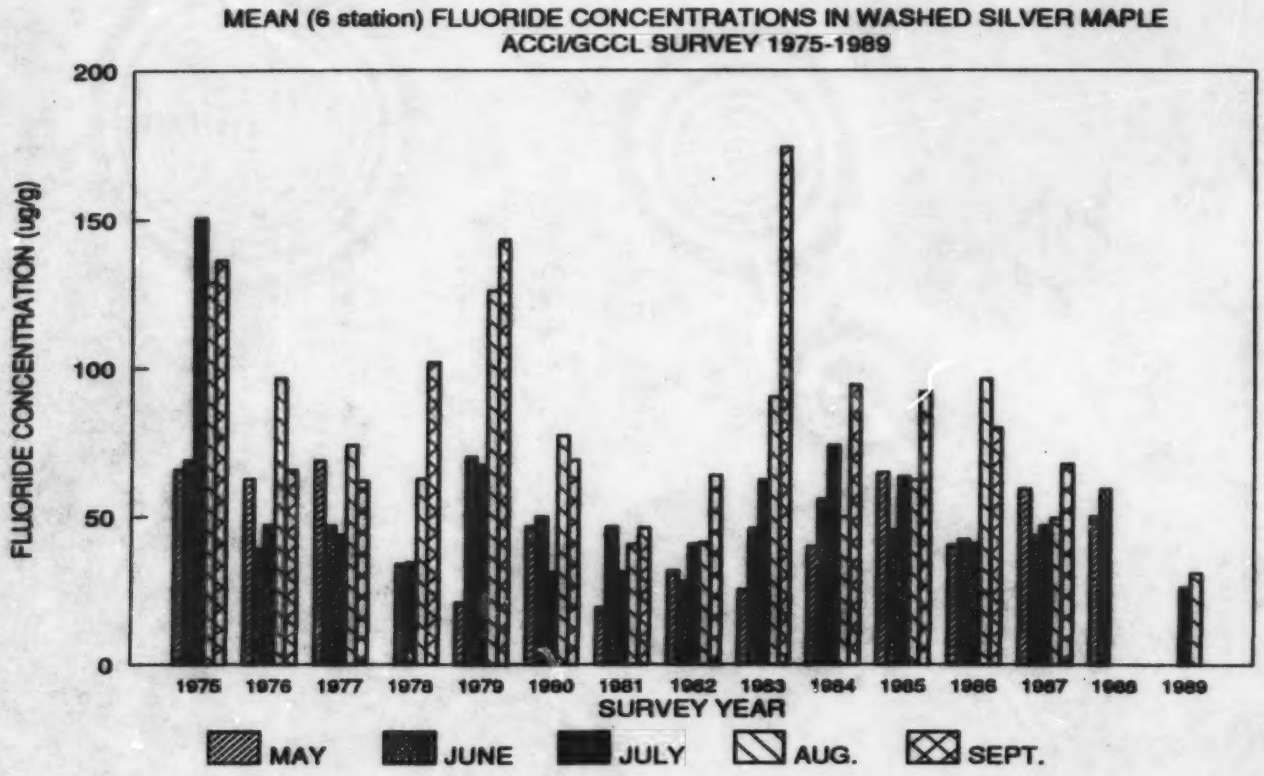

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FIGURE 8:

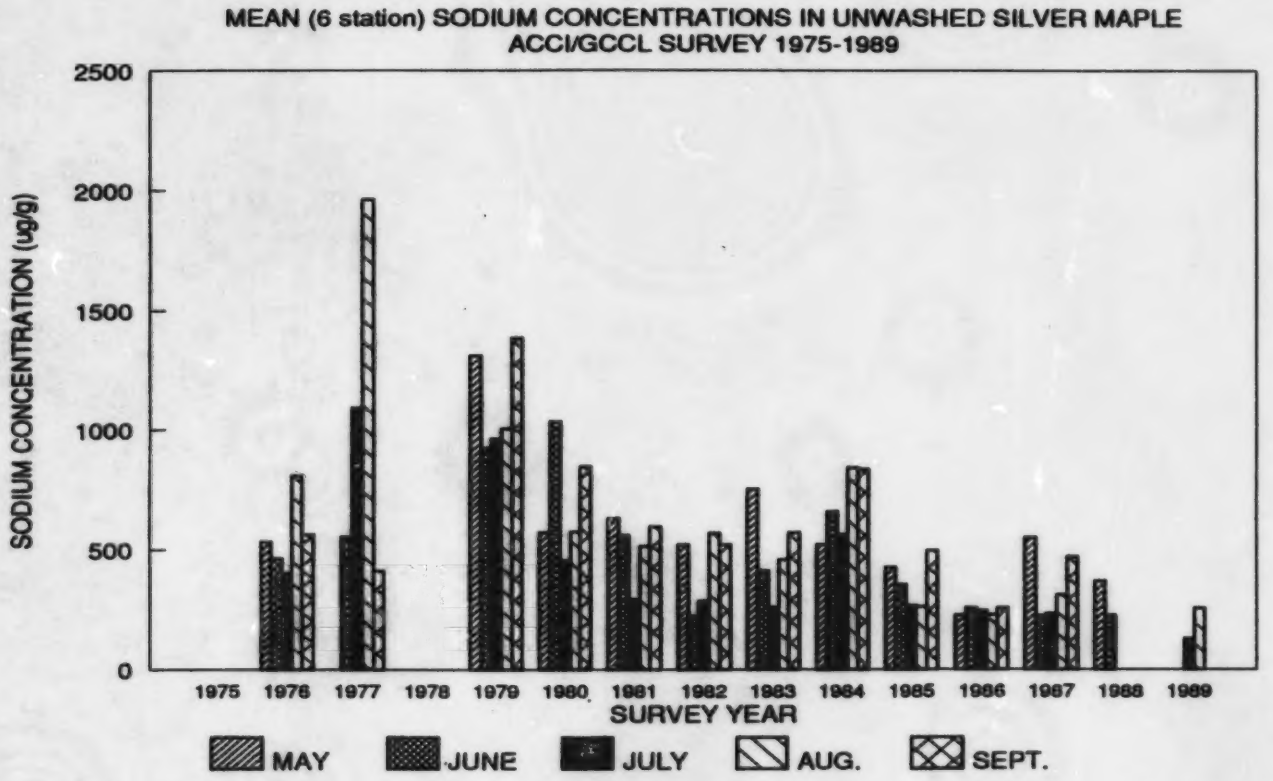

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FIGURE 9:

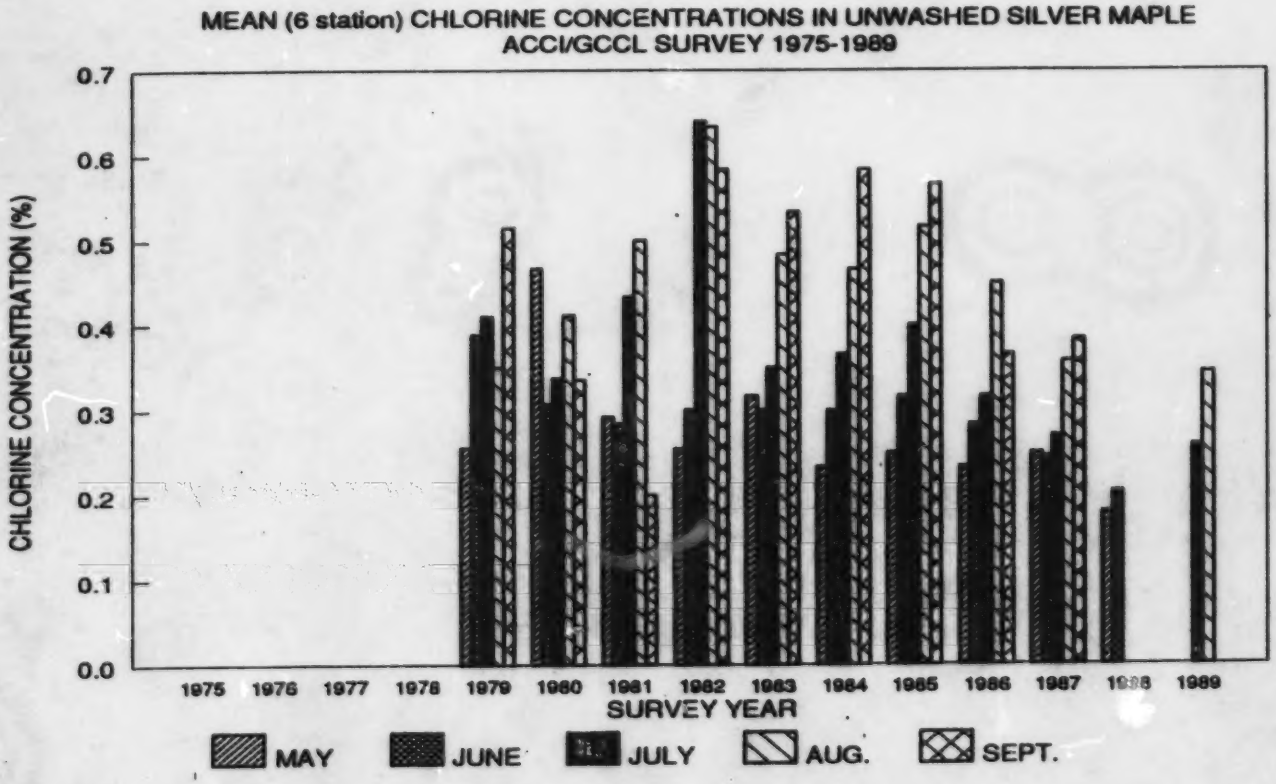

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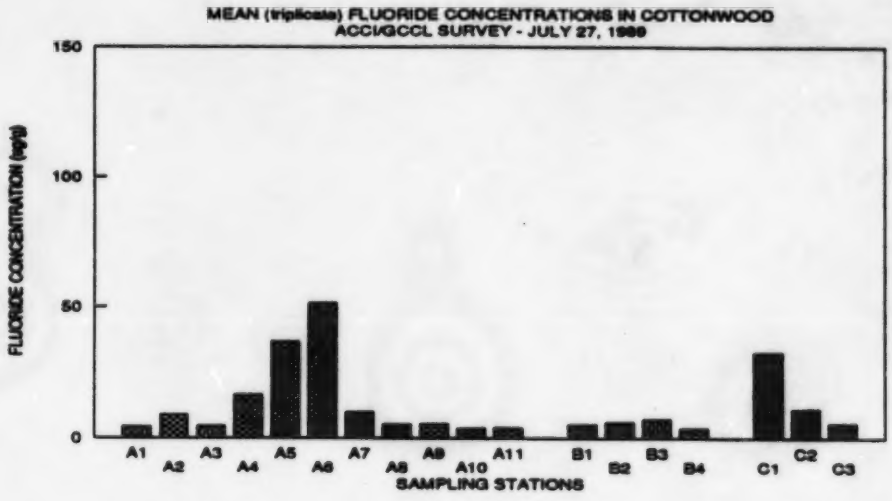
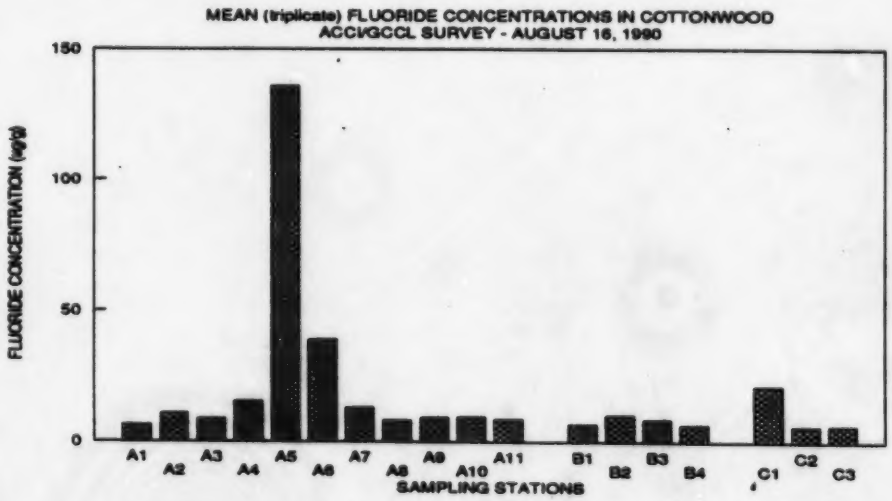
FIGURE 10: COTTONWOOD STATION LOCATIONS - ACCI/GCCL SURVEY - 1989 & 1990

FIGURE 11a:



D:\AG-90-90\CTWOFF90.CGM

FIGURE 11b:



D:\AG-90-90\CTWOFF90.CGM

FIGURE 12a:

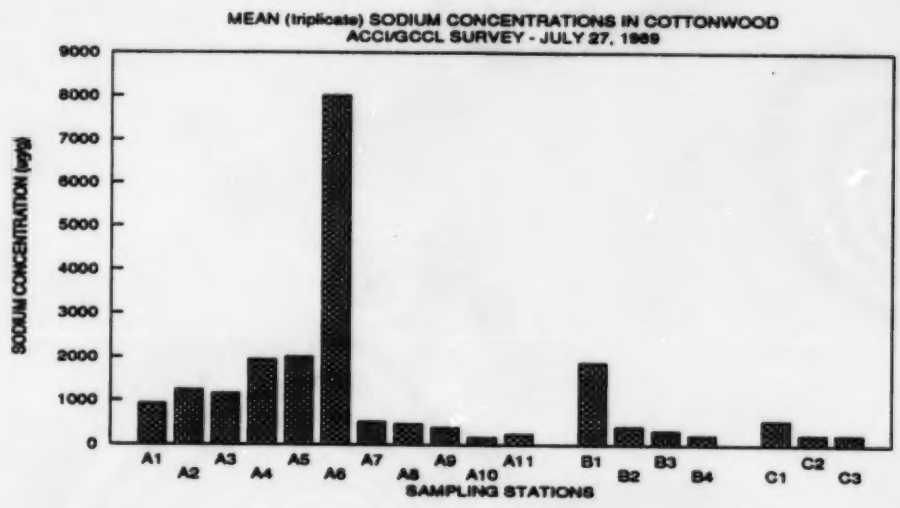


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FIGURE 12b:

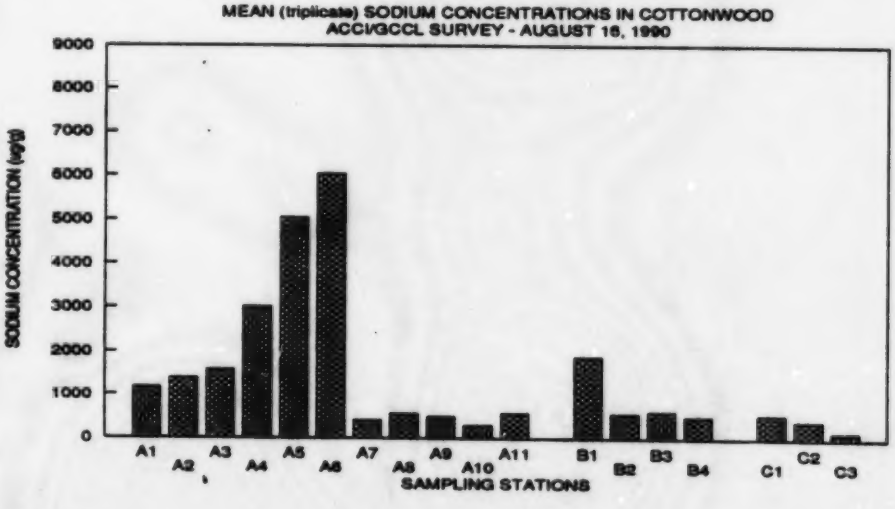

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FIGURE 13a:

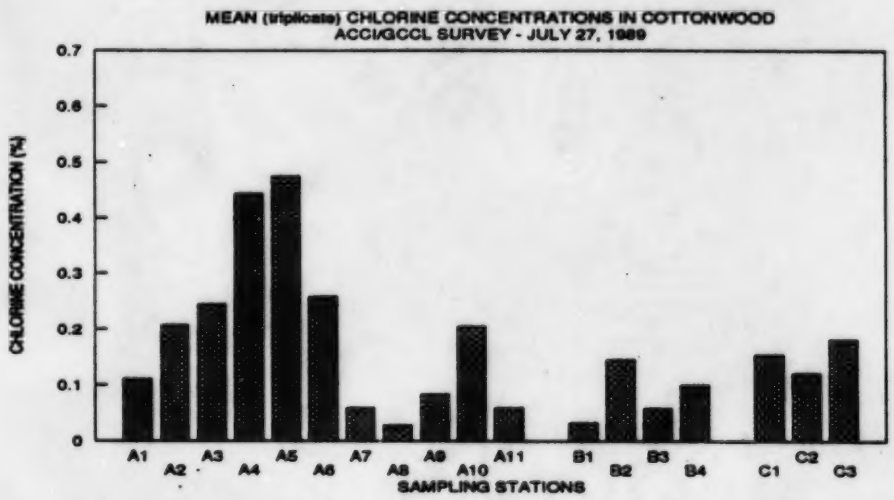

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FIGURE 13b:

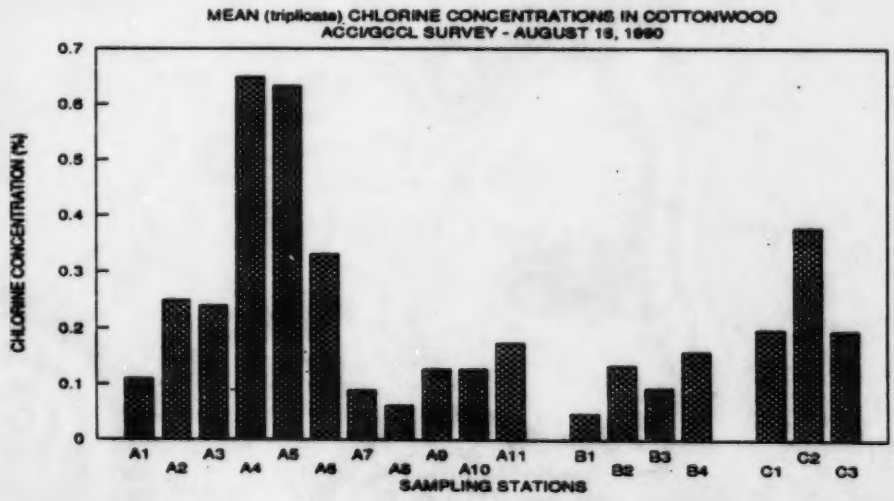

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FIGURE 14a:

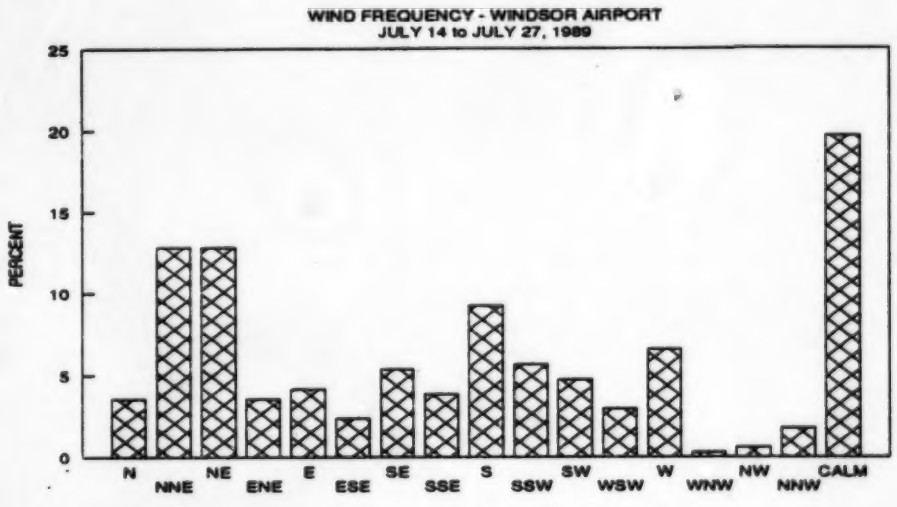

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FIGURE 14b:

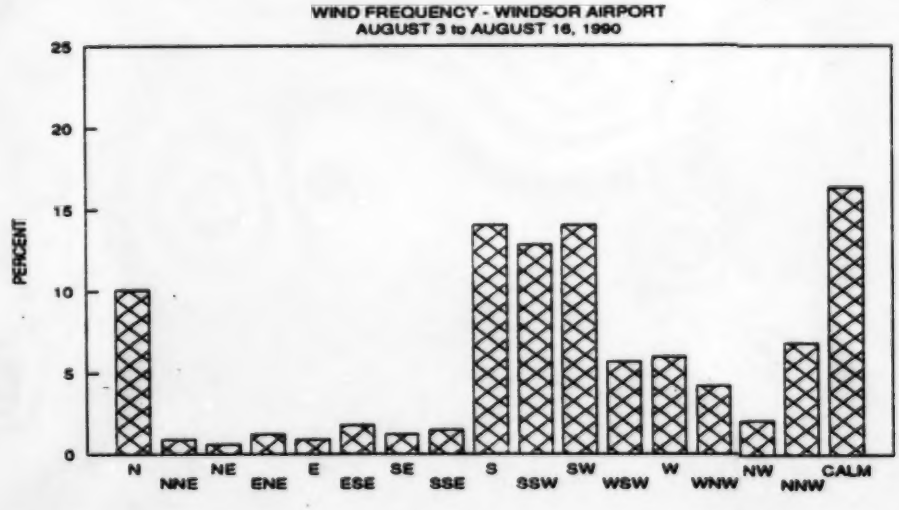

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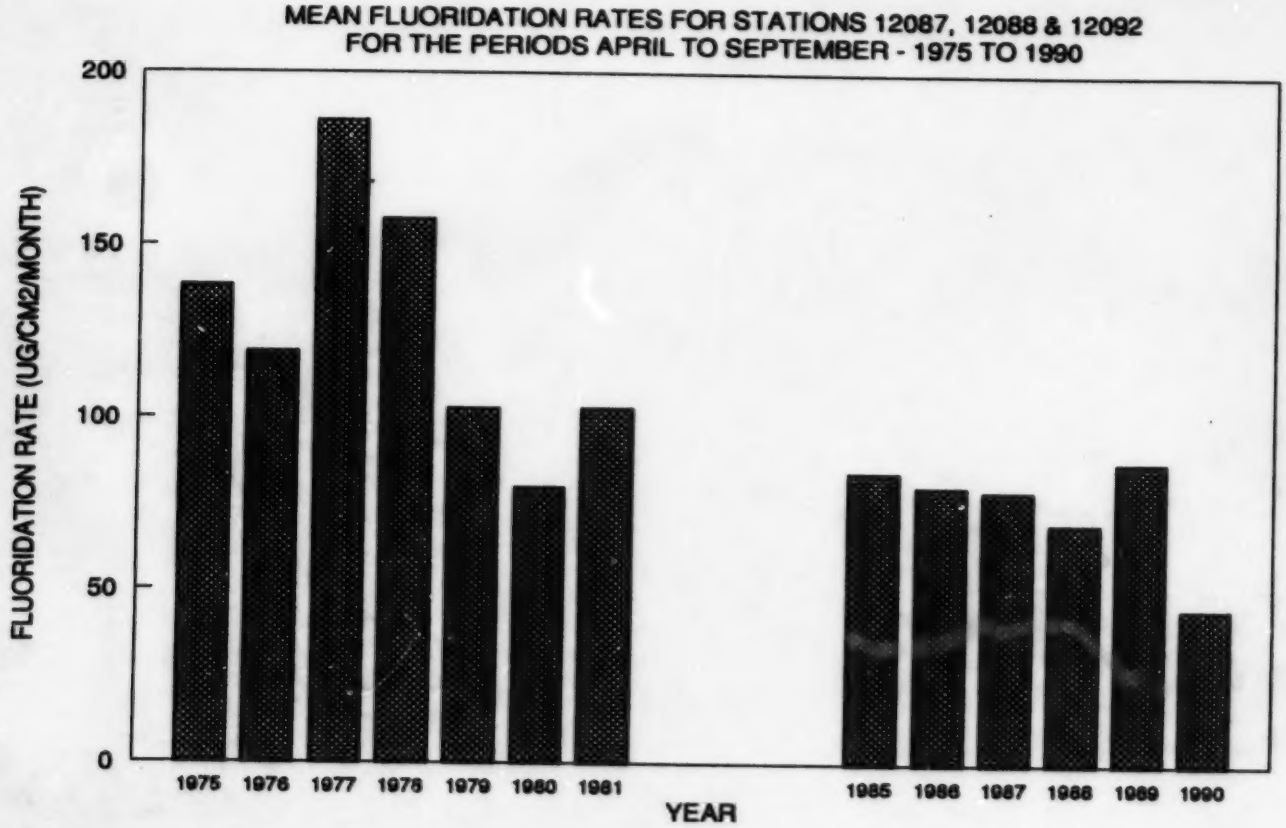
FIGURE 15:



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8 Appendix 1: Silver Maple Foliage Concentrations

Station	Sampling Date	Repl	F w	F uw	Na uw	Cl uw	Ca uw		F w	F uw	Na uw	Cl uw	Ca uw
1	May 30/88	1	99	140	290	0.14	9800	Mean	113	157	310	0.14	9467
1		2	130	170	290	0.14	10000	STD	13	12	28	0.00	618
1		3	110	160	350	0.14	8600						
1	Jun 28/88	1	130	140	190	0.12	11000	Mean	123	143	183	0.11	10800
1		2	110	150	200	0.12	9400	STD	9	5	17	0.02	1071
1		3	130	140	160	0.08	12000						
1	Jul 26/89	1	66	91	180	0.27	9000	Mean	65	87	180	0.23	9267
1		2	56	81	160	0.29	9100	STD	7	4	16	0.08	309
1		3	72	90	200	0.12	9700						
1	Sep 05/89	1	89	120	150	0.20	9500	Mean	73	119	177	0.32	7867
1		2	61	117	160	0.35	6800	STD	12	1	31	0.08	1173
1		3	69	120	220	0.40	7300						
12	May 30/88	1	19	7	140	0.07	8500	Mean	13	13	137	0.07	8233
12		2	7	19	140	0.06	9400	STD	5	5	5	0.00	1078
12		3	12	13	130	0.07	6800						
12	Jun 28/88	1	13	15	100	0.09	13000	Mean	13	15	103	0.08	13000
12		2	14	12	99	0.09	13000	STD	1	2	5	0.01	0
12		3	12	17	110	0.07	13000						
12	Jul 26/89	1	4	4	52	0.33	11000	Mean	4	5	53	0.21	10333
12		2	5	6	52	0.16	10000	STD	0	1	2	0.09	471
12		3	5	4	56	0.14	10000						
12	Sep 05/89	1	9	10	65	0.25	12000	Mean	8	11	66	0.25	12667
12		2	7	10	57	0.23	11000	STD	1	2	8	0.01	1700
12		3	8	13	76	0.26	15000						
16	May 30/88	1	76	170	500	0.34	11000	Mean	77	160	467	0.34	11000
16		2	83	140	400	0.35	10000	STD	5	14	47	0.01	816
16		3	71	170	500	0.32	12000						
16	Jun 28/88	1	85	200	330	0.33	21000	Mean	102	203	357	0.52	15667
16		2	110	210	400	0.60	13000	STD	12	5	31	0.14	3771
16		3	110	200	340	0.64	13000						
16	Jul 26/89	1	21	30	120	0.60	15000	Mean	20	30	117	0.44	12800
16		2	19	28	110	0.28	14000	STD	1	2	5	0.13	2439
16		3	21	33	120	0.45	9400						
16	Sep 05/89	1	49	147	590	0.72	12000	Mean	55	140	443	0.58	10967
16		2	63	133	360	0.55	11000	STD	6	6	104	0.10	858
16		3	53	140	380	0.47	9900						
18	May 30/88	1	41	76	540	0.19	11000	Mean	34	69	453	0.18	9600
18		2	27	72	460	0.16	8800	STD	6	7	74	0.01	993
18		3	34	60	360	0.19	9000						
18	Jun 28/88	1	49	90	410	0.26	12000	Mean	44	88	350	0.26	13000
18		2	39	64	270	0.20	13000	STD	4	19	59	0.04	816
18		3	45	110	370	0.31	14000						
18	Jul 26/89	1	18	42	140	0.32	10000	Mean	28	38	114	0.31	9933
18		2	39	38	140	0.36	11000	STD	9	3	37	0.05	899
18		3	28	34	62	0.25	8800						
18	Sep 05/89	1	21	57	170	0.41	14000	Mean	26	54	183	0.44	13333
18		2	30	61	210	0.49	14000	STD	4	8	19	0.04	943
18		3	27	43	170	0.41	12000						
29	May 30/88	1	26	74	74	0.06	7800	Mean	27	74	78	0.07	8533
29		2	26	72	78	0.08	8800	STD	1	1	3	0.01	525
29		3	28	75	82	0.06	9000						
29	Jun 28/88	1	35	55	75	0.08	12000	Mean	41	61	75	0.10	10167
29		2	47	60	77	0.10	9100	STD	5	5	2	0.01	1302
29		3	40	68	73	0.11	9400						

Station	Sampling Date	Repl	F w	F uw	Na uw	Cl uw	Ca uw		F w	F uw	Na uw	Cl uw	Ca uw
29	Jul 26/89	1	11	15	59	0.19	12000	Mean	10	11	45	0.18	11000
29		2	10	9	35	0.18	11000	STD	1	3	10	0.01	816
29		3	9	10	40	0.16	10000						
29	Sep 05/89	1	7	11	60	0.27	14000	Mean	6	11	58	0.25	13667
29		2	7	9	63	0.25	15000	STD	0	1	5	0.02	1247
29		3	6	12	52	0.23	12000						
30	May 30/88	1	6	16	100	0.10	12000	Mean	7	19	127	0.11	12667
30		2	7	25	140	0.12	14000	STD	1	4	19	0.01	943
30		3	9	17	140	0.10	12000						
30	Jun 28/88	1	10	19	88	0.06	7200	Mean	12	19	106	0.06	8300
30		2	13	19	120	0.05	9200	STD	2	0	13	0.01	829
30		3	14	18	110	0.06	8500						
30	Jul 26/89	1	3	3	120	0.07	6700	Mean	4	4	99	0.09	8033
30		2	4	5	80	0.11	6400	STD	1	0	16	0.02	2101
30		3	5	4	96	0.10	11000						
30	Sep 05/89	1	11	23	240	0.09	9500	Mean	10	23	227	0.10	8200
30		2	10	24	200	0.07	6900	STD	0	0	19	0.02	1061
30		3	10	23	240	0.12	8200						
31	May 30/88	1	46	75	760	0.24	11000	Mean	42	87	787	0.24	11667
31		2	38	100	800	0.29	12000	STD	3	10	19	0.04	471
31		3	43	86	800	0.18	12000						
31	Jun 28/88	1	34	50	260	0.15	11000	Mean	34	54	290	0.17	11667
31		2	35	62	290	0.15	13000	STD	1	6	24	0.02	943
31		3	33	50	320	0.20	11000						
31	Jul 26/89	1	32	41	230	0.26	10000	Mean	31	35	223	0.30	10667
31		2	19	24	200	0.26	10000	STD	10	8	17	0.06	943
31		3	43	41	240	0.39	12000						
31	Sep 05/89	1	18	34	290	0.33	7600	Mean	16	33	443	0.38	12533
31		2	19	36	610	0.52	13000	STD	3	3	131	0.10	3852
31		3	12	28	430	0.30	17000						
32	May 30/88	1	32	85	220	0.08	7200	Mean	20	46	180	0.08	6700
32		2	14	30	180	0.08	7100	STD	8	28	33	0.00	638
32		3	14	22	140	0.07	5800						
32	Jun 28/88	1	38	49	93	0.10	5800	Mean	38	58	103	0.09	6333
32		2	45	71	120	0.08	7300	STD	6	9	12	0.01	685
32		3	31	54	97	0.09	5900						
32	Jul 26/89	1	34	34	80	0.13	11000	Mean	27	27	84	0.12	10467
32		2	23	22	84	0.12	8400	STD	5	5	3	0.00	1517
32		3	25	25	87	0.12	12000						
32	Sep 05/89	1	10	15	110	0.06	13000	Mean	10	15	120	0.08	10400
32		2	12	16	140	0.08	9100	STD	1	1	14	0.01	1838
32		3	9	14	110	0.10	9100						
15	May 30/88	1	7	9	46	0.12	6200	Mean	4	6	44	0.10	5833
15		2	2	3	45	0.11	6100	STD	2	2	2	0.02	450
15		3	4	5	41	0.08	5200						
15	Jun 28/88	1	6	7	37	0.16	8200	Mean	6	8	41	0.13	8767
15		2	6	10	42	0.13	8100	STD	0	1	3	0.02	873
15		3	5	7	45	0.11	10000						
15	Jul 26/89	1	4	4	13	0.20	9600	Mean	2	3	20	0.24	10533
15		2	2	3	24	0.28	11000	STD	1	1	5	0.03	660
15		3	1	2	22	0.24	11000						
15	Sep 05/89	1	3	4	48	0.30	11000	Mean	3	4	36	0.27	10633
15		2	3	3	33	0.25	8900	STD	0	0	9	0.02	1292
15		3	3	4	26	0.27	12000						

9 Appendix 2: Cottonwood Foliage Concentrations

Station	Sampling Date	Repl	F uw	Na uw	Cl uw	Ca uw		F uw	Na uw	Cl uw	Ca uw
A1	Jul 27/89	1	3.9	690	0.09	21000	Mean	4.1	930	0.11	21667
A1		2	4.2	1000	0.11	24000	STD	0.2	175	0.02	1700
A1		3	4.3	1100	0.13	20000					
A2	Jul 27/89	1	6.7	1000	0.15	23000	Mean	8.9	1233	0.21	28000
A2		2	10.0	1300	0.23	32000	STD	1.6	170	0.04	3742
A2		3	10.0	1400	0.24	29000					
A3	Jul 27/89	1	4.9	1100	0.22	24000	Mean	4.8	1167	0.24	25667
A3		2	5.1	1300	0.28	26000	STD	0.3	94	0.03	1247
A3		3	4.3	1100	0.23	27000					
A4	Jul 27/89	1	13.0	1600	0.53	28000	Mean	16.3	1933	0.44	26667
A4		2	21.0	2600	0.48	27000	STD	3.4	471	0.09	1247
A4		3	15.0	1600	0.32	25000					
A5	Jul 27/89	1	38.0	2400	0.47	17000	Mean	36.7	2000	0.47	16000
A5		2	40.0	2000	0.49	16000	STD	3.4	327	0.01	816
A5		3	32.0	1600	0.46	15000					
A6	Jul 27/89	1	51.0	8200	0.26	19000	Mean	51.3	8000	0.26	18000
A6		2	57.0	8200	0.26	19000	STD	4.5	283	0.01	1414
A6		3	46.0	7600	0.25	16000					
A7	Jul 27/89	1	9.0	430	0.05	26000	Mean	9.7	520	0.06	29333
A7		2	9.0	390	0.07	27000	STD	0.9	156	0.01	4028
A7		3	11.0	740	0.06	35000					
A8	Jul 27/89	1	5.2	510	0.03	25000	Mean	5.1	467	0.03	26000
A8		2	5.1	440	0.03	28000	STD	0.1	31	0.00	1414
A8		3	5.0	450	0.03	25000					
A9	Jul 27/89	1	5.1	310	0.08	21000	Mean	5.3	390	0.08	20667
A9		2	5.2	440	0.08	21000	STD	0.2	57	0.00	471
A9		3	5.6	420	0.08	20000					
A10	Jul 27/89	1	4.1	170	0.21	28000	Mean	3.6	160	0.20	26667
A10		2	2.9	130	0.15	23000	STD	0.5	22	0.04	2625
A10		3	3.8	180	0.25	29000					
A11	Jul 27/89	1	3.4	210	0.05	24000	Mean	3.8	233	0.06	23000
A11		2	4.6	260	0.08	25000	STD	0.5	21	0.02	2160
A11		3	3.5	230	0.04	20000					
B1	Jul 27/89	1	4.4	2000	0.03	20000	Mean	5.0	1867	0.03	20333
B1		2	5.0	2300	0.03	22000	STD	0.5	419	0.01	1247
B1		3	5.6	1300	0.04	19000					
B2	Jul 27/89	1	5.5	440	0.14	28000	Mean	5.9	410	0.14	28000
B2		2	6.4	350	0.15	29000	STD	0.4	42	0.01	816
B2		3	5.8	440	0.14	27000					
B3	Jul 27/89	1	6.2	260	0.05	24000	Mean	6.9	313	0.06	23667
B3		2	8.9	400	0.06	24000	STD	1.4	62	0.00	471
B3		3	5.7	280	0.06	23000					
B4	Jul 27/89	1	3.0	170	0.09	16000	Mean	3.5	203	0.10	15667
B4		2	3.4	210	0.10	15000	STD	0.4	25	0.01	471
B4		3	4.0	230	0.11	16000					
C1	Jul 27/89	1	34.0	600	0.16	23000	Mean	32.3	543	0.15	22667
C1		2	30.0	480	0.14	23000	STD	1.7	49	0.01	471
C1		3	33.0	550	0.16	22000					
C2	Jul 27/89	1	11.0	220	0.12	19000	Mean	10.7	230	0.12	20333
C2		2	12.0	200	0.12	21000	STD	1.2	29	0.00	943
C2		3	9.1	270	0.12	21000					
C3	Jul 27/89	1	5.3	180	0.19	26000	Mean	5.6	227	0.18	24667
C3		2	6.0	230	0.22	27000	STD	0.3	37	0.04	2625
C3		3	5.4	270	0.13	21000					

Station	Sampling Date	Repl	F ug/g	Na ug/g	Cl %	Ca ug/g		F uw	Na uw	Cl uw	Ca uw
A1	Aug 16/90	1	6.1	1200	0.10	22000	Mean	6.2	1180	0.11	23333
A1		2	6.4	1400	0.12	24000	STD	0.1	188	0.01	943
A1		3	6.2	940	0.11	24000					
A2	Aug 16/90	1	11.0	1500	0.26	36000	Mean	10.9	1367	0.25	30333
A2		2	9.7	1000	0.18	24000	STD	0.9	262	0.05	4922
A2		3	12.0	1600	0.31	31000					
A3	Aug 16/90	1	7.2	1600	0.23	27000	Mean	8.8	1567	0.24	26000
A3		2	13.0	1500	0.24	27000	STD	3.0	47	0.01	1414
A3		3	6.3	1600	0.25	24000					
A4	Aug 16/90	1	11.0	2700	0.48	21000	Mean	15.3	3000	0.65	28333
A4		2	18.0	3400	0.78	35000	STD	3.1	294	0.13	5735
A4		3	17.0	2900	0.69	29000					
A5	Aug 16/90	1	127.7	6400	0.57	19000	Mean	135.6	5033	0.63	17667
A5		2	124.2	4900	0.70	17000	STD	13.7	1066	0.05	943
A5		3	154.8	3800	0.63	17000					
A6	Aug 16/90	1	41.0	6800	0.42	21000	Mean	39.0	6033	0.33	18333
A6		2	36.0	5100	0.31	17000	STD	2.2	704	0.07	1886
A6		3	40.0	6200	0.26	17000					
A7	Aug 16/90	1	12.0	520	0.09	39000	Mean	13.0	410	0.09	40333
A7		2	14.0	320	0.08	38000	STD	0.8	83	0.01	2625
A7		3	13.0	390	0.10	44000					
A8	Aug 16/90	1	7.8	380	0.05	40000	Mean	8.1	560	0.06	38333
A8		2	8.3	620	0.07	34000	STD	0.2	130	0.01	3091
A8		3	8.2	680	0.07	41000					
A9	Aug 16/90	1	9.0	390	0.13	22000	Mean	9.4	490	0.13	21333
A9		2	10.0	630	0.12	20000	STD	0.4	102	0.01	943
A9		3	9.3	450	0.13	22000					
A10	Aug 16/90	1	9.5	310	0.15	37000	Mean	9.5	297	0.13	34000
A10		2	9.2	250	0.11	33000	STD	0.2	34	0.02	2160
A10		3	9.7	330	0.12	32000					
A11	Aug 16/90	1	9.0	530	0.17	26000	Mean	8.6	573	0.17	26000
A11		2	7.9	610	0.16	24000	STD	0.5	33	0.01	1633
A11		3	9.0	580	0.19	28000					
B1	Aug 16/90	1	7.9	1500	0.05	21000	Mean	6.7	1867	0.05	20667
B1		2	6.4	1400	0.05	25000	STD	0.9	591	0.01	3682
B1		3	5.7	2700	0.04	16000					
B2	Aug 16/90	1	9.3	510	0.08	40000	Mean	10.1	553	0.13	39000
B2		2	10.0	510	0.13	36000	STD	0.7	61	0.05	2160
B2		3	11.0	640	0.19	41000					
B3	Aug 16/90	1	10.0	650	0.11	39000	Mean	8.3	607	0.09	32667
B3		2	8.0	550	0.08	33000	STD	1.2	42	0.01	5312
B3		3	7.0	620	0.08	26000					
B4	Aug 16/90	1	6.7	500	0.18	23000	Mean	6.4	483	0.16	21000
B4		2	6.6	490	0.12	18000	STD	0.3	17	0.03	2160
B4		3	6.0	460	0.17	22000					
C1	Aug 16/90	1	27.0	690	0.25	29000	Mean	21.0	530	0.20	28333
C1		2	14.0	350	0.15	30000	STD	5.4	140	0.04	1700
C1		3	22.0	550	0.19	26000					
C2	Aug 16/90	1	5.3	270	0.36	17000	Mean	5.9	400	0.38	17000
C2		2	6.4	560	0.38	16000	STD	0.5	120	0.01	816
C2		3	6.1	370	0.39	18000					
C3	Aug 16/90	1	7.2	190	0.21	29000	Mean	6.2	143	0.19	25000
C3		2	5.3	120	0.16	20000	STD	0.8	33	0.02	3742
C3		3	6.1	120	0.21	26000					

10 Appendix 3: Fluoridation Rates, 1975 to 1990

Station 12053

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975								
1976								
1977								
1978								
1979								
1980								
1981	**57**	**51**	**42**	38	38	28	6	3
1982								
1983								
1984								
1985	25	11	10	16	10	16	6	0
1986	19	20				20	3	0
1987	34	**114**	**46**	21	**66**	21	6	3
1988	13		17	23	5	32	5	0
1989	19	21	20	19	**42**	18	6	1
1990	20	12	14	23	15	14	6	0

Station 12074

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975	36	26	23	17	**41**	23	6	1
1976	27	19	8	9	37	29	6	0
1977	37	**42**	22	25	24	25	6	1
1978	19	23	20	21	28	25	6	0
1979	19	27	12	1	24	16	6	0
1980	6	18	18	18	5		5	0
1981	26	25	23	16	20	36	6	0
1982								
1983								
1984								
1985	17	15	12	15	8	14	6	0
1986	14	18				17	3	0
1987	34	35	30	20	23	11	6	0
1988	30	27	18	40	6	23	6	0
1989	19	23	19	21	35	20	6	0
1990	18	10	18	22	23	11	6	0

Station 12087

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975		**65**	**106**	**55**	**75**	**125**	5	5
1976	**85**	**45**	**56**	40	**70**	**88**	6	5
1977	**130**	**140**	**45**	**63**	**54**	**45**	6	6
1978	29	**43**	34	**52**	**916**	**86**	6	4
1979	**43**	38	35	**48**		35	5	2
1980	**70**	**62**	31	**63**	38		5	3
1981	**41**	**47**	**75**	**55**	**57**	**55**	6	6
1982								
1983								
1984								
1985	**51**	37	25	33	25	29	6	1
1986	31	25				40	3	0
1987	24	**59**	**55**	**42**	39	**43**	6	4
1988	**98**	**42**	**50**	**46**	12	31	6	4
1989	25	**47**	**62**	34	**60**	26	6	3
1990	**49**	32	24	27	24	23	6	1

Station 12088

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975		**161**	**184**	**147**	**193**	**458**	5	5
1976	**480**	**190**	**190**	**83**	**167**	**238**	6	6
1977	**901**	**720**	**149**	**169**	**213**	**107**	6	6
1978	**49**	**105**	**574**	**121**	**346**	**87**	6	6
1979	**115**	**351**	**335**	**170**		**111**	5	5
1980	**98**	**203**	**178**	**177**	**68**		5	5
1981	**259**	**405**	**200**	**86**	**81**	**120**	6	5
1982								
1983								
1984								
1985	**322**	**222**	**107**	**149**	**80**	**95**	6	6
1986	**150**	**64**				**262**	3	3
1987	**80**	**310**	**135**	**99**	**124**	**105**	6	6
1988	**80**	**104**	**67**	**199**	**44**	**126**	6	6
1989	**156**	**185**	**134**	**101**	**132**	**179**	6	6
1990	**141**	**72**	**42**	**55**	38	**46**	6	5

Station 12092

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975		**98**	**139**	36	**145**	**86**	5	4
1976	**124**	**84**	33	**43**	**98**	24	6	4
1977	**169**	**110**		**55**	**51**	**43**	5	5
1978	**102**	**86**	39	**42**	**60**	**65**	6	5
1979	**47**	40	**64**	**64**		**43**	5	4
1980	38	**79**	29	39	22		5	1
1981	**68**	**117**	**43**	27	**52**	**60**	6	5
1982								
1983								
1984								
1985	**110**	**62**	34	**86**	26	27	6	3
1986	33	**80**				38	3	1
1987	**80**	**46**	**60**	13	**91**	19	6	4
1988	**110**	**82**	**73**	**41**	23	30	6	4
1989	**63**	**64**	**45**	**76**	**128**	**60**	6	6
1990	32	30	18	**10**[illegible]	29	25	6	1

Station 12095

	April	May	June	July	Aug.	Sept.	Observations	Exceedances
1975		**50**	20	22	26	29	5	1
1976	**51**	34	20	27	36	31	6	1
1977	19	20	29	34	29	22	6	0
1978	27	26	22	26	23	37	6	0
1979	29	29	34	31		20	5	0
1980	18	35	21	35	11		5	0
1981	25	**46**	11	17	24	28	6	1
1982								
1983								
1984								
1985	17	26	14	17	12	18	6	0
1986	20	34				20	3	0
1987	24	24	25	22	37	19	6	0
1988	35	**64**	30	30	10	20	6	1
1989	31	40	28	27	**41**	**45**	6	2
1990	22	18	16	26	24	20	6	0

Fluoridation Rates in ug/100cm^2/30 days
Ambient Air Quality Criteria for Fluoridation Rate = 40 ug/100cm^2/30 days, during the period April 1 to September 30
Exceedances highlighted in bold type